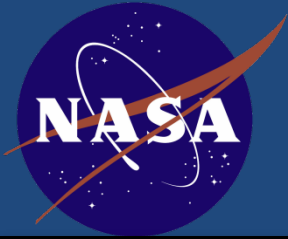


Statistical Analysis of an Infrared Thermography Inspection of Reinforced Carbon-Carbon

Each piece of flight hardware being used on the shuttle must be analyzed and pass NASA requirements before the shuttle is ready for launch. One tool used to detect cracks that lie within flight hardware is Infrared Flash Thermography. This is a non-destructive testing technique which uses an intense flash of light to heat up the surface of a material after which an Infrared camera is used to record the cooling of the material. Since cracks within the material obstruct the natural heat flow through the material, they are visible when viewing the data from the Infrared camera. We used Ecotherm, a software program, to collect data pertaining to the delaminations and analyzed the data using Ecotherm and University of Dayton Log Logistic Probability of Detection (POD) Software. The goal was to reproduce the statistical analysis produced by the University of Dayton software, by using scatter plots, log transforms, and residuals to test the assumption of normality for the residuals.



Statistical Analysis of an Infrared Thermography Inspection on Reinforced Carbon Carbon (RCC)

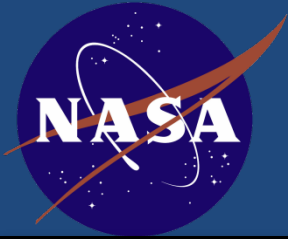
By
Kayla Comeaux



Agenda



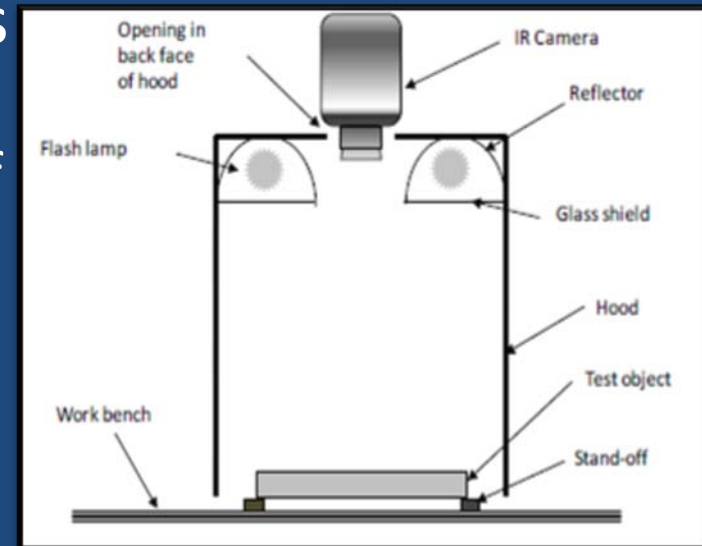
- Background
- Project
 - Objectives
 - \hat{A} vs. A analysis
 - Residuals
 - Test of Normality of Residuals
- Summary
 - Strengths/Weaknesses
 - Future work
 - Acknowledgments



Background: Infrared Thermography Scan



- Reinforced Carbon Carbon (RCC) is the composite material that makes up the nose cone of the shuttle
- Infrared (IR) Thermography is a non-destructive test used to detect cracks beneath the surface of materials
 - Two flash bulbs produce a 26 KJ Flash of energy heats up top surface
 - The heat flow through material is disrupted by defects
 - Infrared Camera is used to measure the cooling of the material. In the Infrared images, defects appear as hot spots on the composite

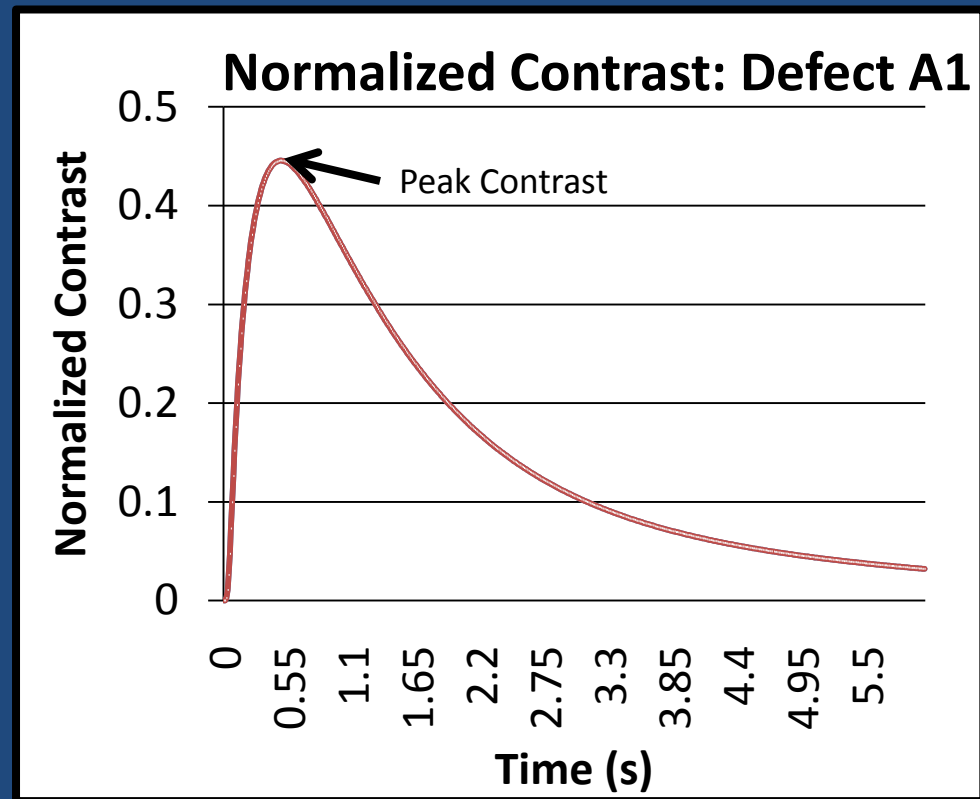


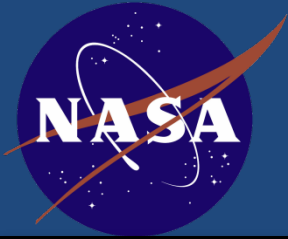


Background: Normalized Contrast of IR Thermography Scan



- Run IR Scan
- Use Ecotherm to analyze data
- Normalized contrast:
$$\frac{(T_i - T_{i_0}) - (T_r - T_{r_0})}{(T_i - T_{i_0}) + (T_r - T_{r_0})}$$
- Find peak normalized contrast (\hat{A}) for each crack of size A.





Project Objectives



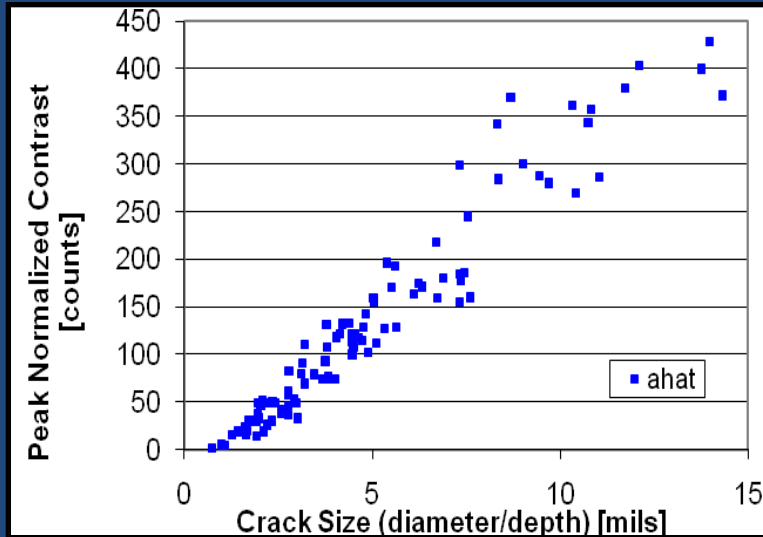
- Recreate the University of Dayton software output
 - \hat{A} vs. A Analysis
 - Residuals of \hat{A} vs. A Analysis
- Test the assumption of normality of residuals
 - Histogram
 - Normal Probability Plot



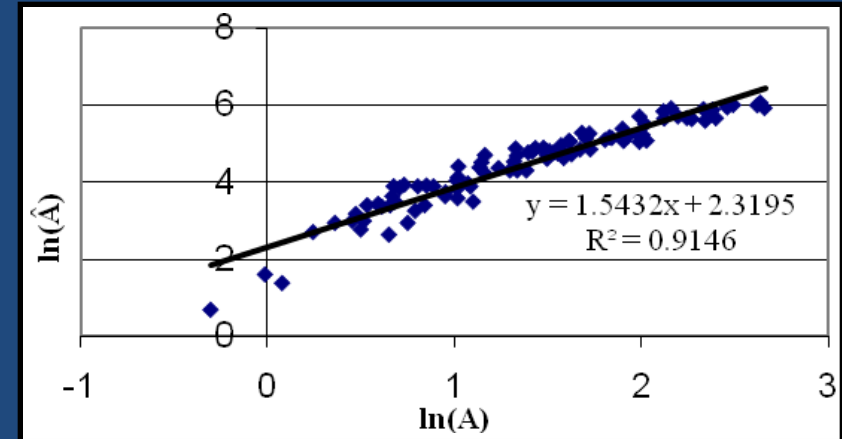
\hat{A} vs. A Analysis



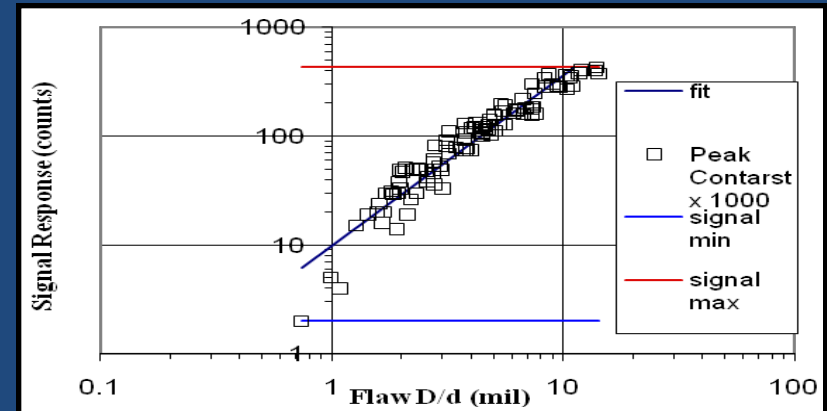
- Scatter Plot



- Log-Log Transform



Software Output:



- $\ln(\hat{A}) = 1.5432 \ln(A) + 2.3195$

- $e^{\ln(\hat{A})} = e^{1.5432 \ln(A) + 2.3195}$

- $\hat{A} = 10.170588 A^{1.5432}$

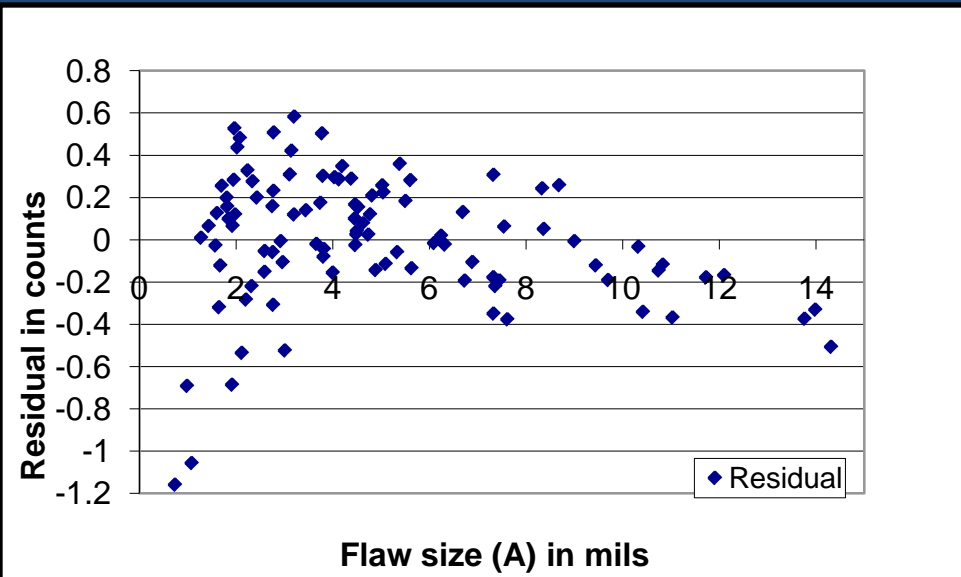


Residuals

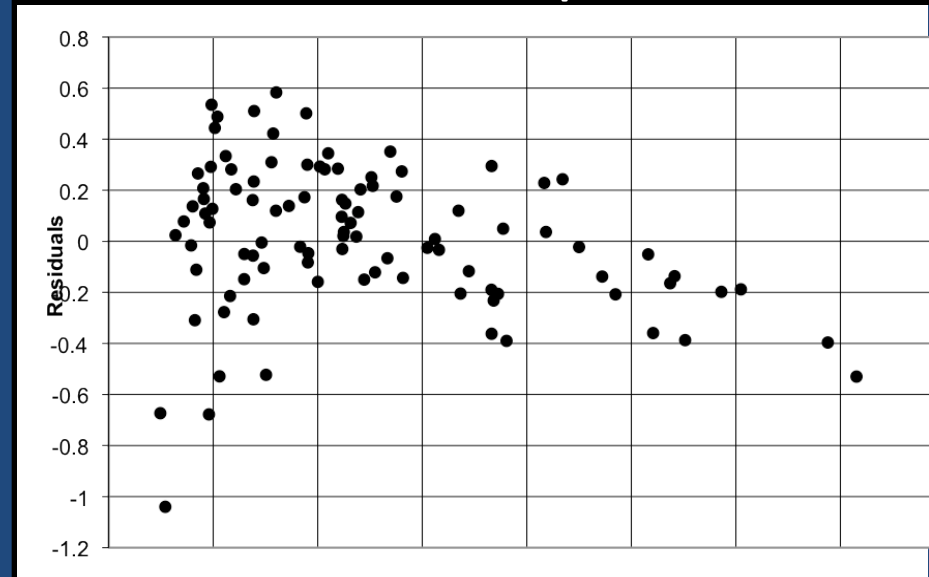


- Residual of A = $\ln(\hat{A}) - (1.5432\ln(A) + 2.3195)$

Created Residual Plot:



Software output:

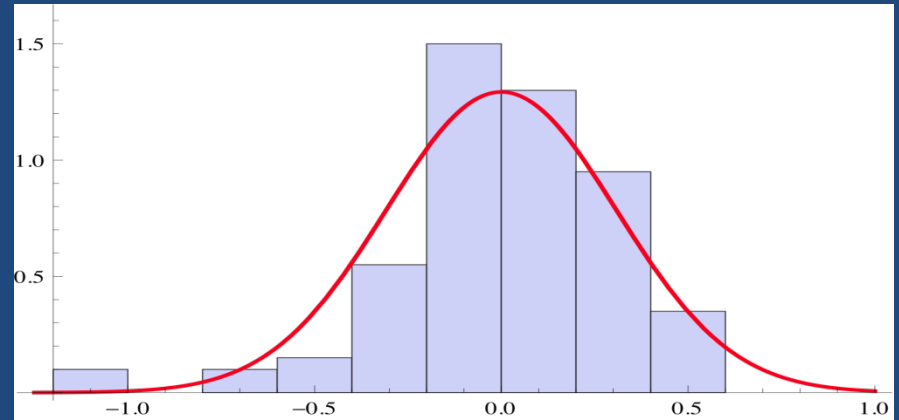


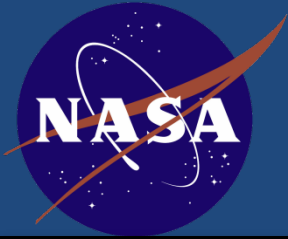


Test of Normality of \hat{A} vs. A Residuals



- Histogram
 - Skewed Left
 - Mean: - 0.00008569
 - Standard Deviation: 0.3086

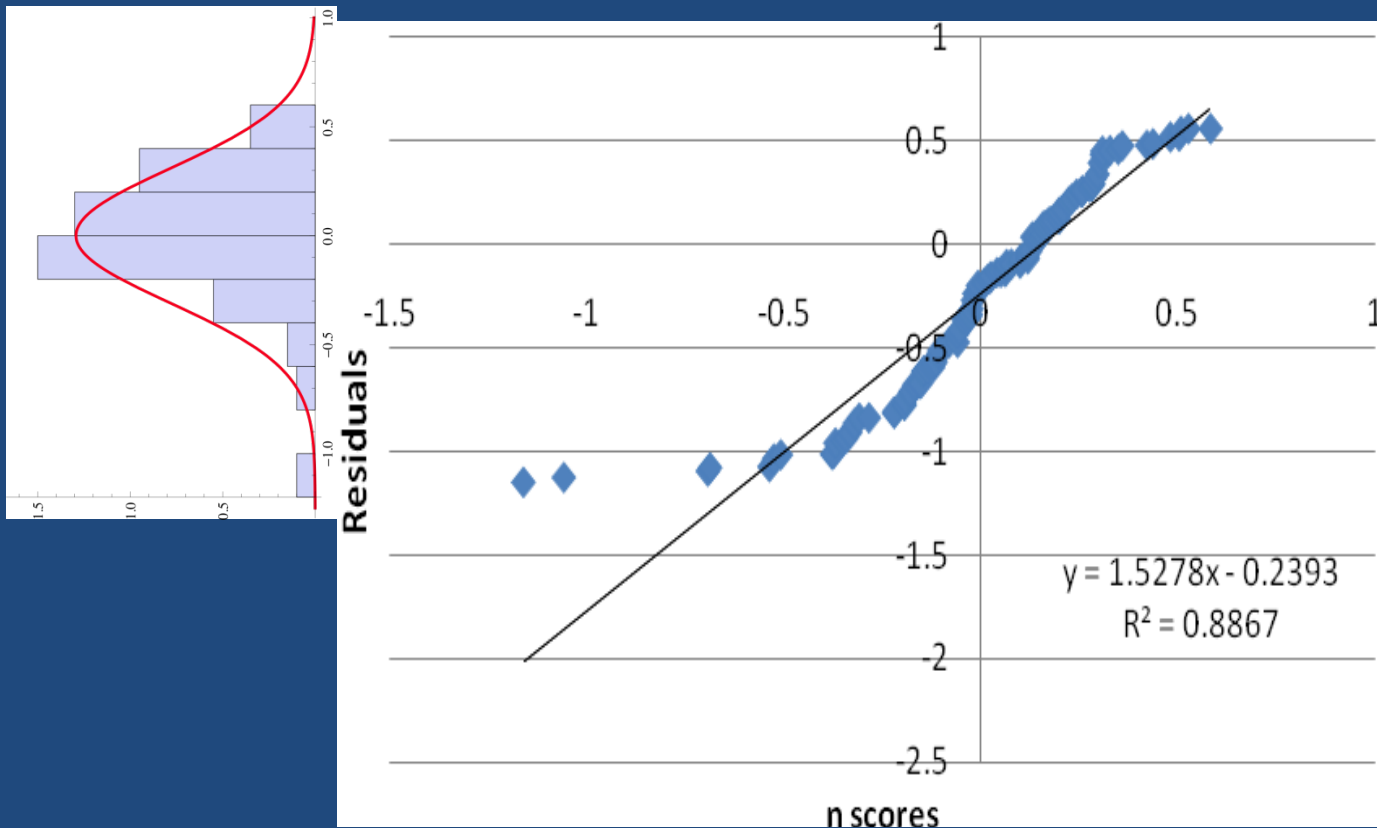




Test of Normality of \hat{A} vs. A Residuals



- Normal Probability Plot

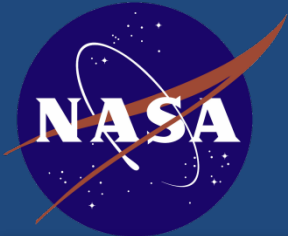




Conclusions



- The graphical output of the software is accurate.
- The assumption of normality of residuals is correct.
 - However more data will make the residuals either more normal or less normal.



Future Work



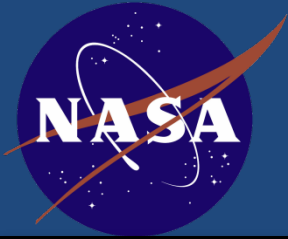
- Statistically analyze the assumptions of the University of Dayton Software as the thresholds of the IR thermography scan are changed.



Acknowledgements



- Mentors: Ajay Koshti & David Stanley
- Dr. Shelton
- Pi Mu Epsilon
- NASA MUST Program



Exit Presentation: Infrared Thermography on Graphite/Epoxy



Thank You